

What is claimed is:

1. A lens distance-varying mechanism for  
varying a distance between a first lens group and a second  
lens group, said lens distance-varying mechanism  
5 comprising:

a first lens frame which holds said first lens  
group;

a second lens frame which holds said second lens  
group, said second lens frame being rotatable relative to  
10 said first lens frame within a predetermined angle of  
rotation;

a relative-moving mechanism for moving said first  
lens frame and said second lens frame to change a relative  
position therebetween on an optical axis when said second  
15 lens frame is positioned at each of forward and reverse  
rotation extremities of said second lens frame relative  
to said first lens frame;

a differential linking ring which rotates together  
with said second lens frame;

20 a differential ring which is rotated relative to  
said differential linking ring by a first angle of rotation  
greater than a second angle of rotation of said second lens  
frame relative to said first lens frame; and

a biasing member, positioned between said  
25 differential ring and said differential linking ring, for

absorbing a difference between said first angle of rotation and said second angle of rotation.

2. The lens distance-varying mechanism according to claim 1, wherein said biasing member  
5 comprises a torsion coil spring.

3. The lens distance-varying mechanism according to claim 2, wherein said torsion coil spring comprises a coil portion and a pair of engaging radial projections which project radially outwards from opposite  
10 ends of said coil portion, respectively,

wherein said coil portion is engaged with said differential linking ring by friction, and

wherein said pair of engaging radial projections project radially outwards from a pair of radial through  
15 holes which are formed on said differential linking ring to hold a rotation transfer projection formed on said differential ring.

4. The lens distance-varying mechanism according to claim 3, wherein said coil portion is fitted  
20 in said differential linking ring to be engaged with an inner peripheral surface thereof by friction.

5. The lens distance-varying mechanism according to claim 3, wherein said pair of engaging radial projections of said torsion coil spring are in pressing  
25 contact with opposite surfaces of said rotation transfer

projection in a circumferential direction of said differential ring in opposite directions towards each other.

6. The lens distance-varying mechanism  
5 according to claim 1, wherein said relative-moving mechanism comprises:

at least one inclined cam edge formed on a peripheral surface of one of said first lens frame and said second lens frame; and

10 at least one cam follower formed on a peripheral surface of the other of said first lens frame and said second lens frame to be engaged with said inclined cam edge.

7. The lens distance-varying mechanism  
15 according to claim 1, wherein said first lens group and said second lens group serve as movable lens groups of a zoom lens system,

wherein said relative-moving mechanism varies a distance between said first lens group and said second lens  
20 group between a first distance in a wide-angle range which ranges from a short focal length extremity to an intermediate focal length and a second distance in a telephoto range which ranges from said intermediate focal length to a long focal length extremity; and

25 wherein said first lens group and said second lens

group move along said optical axis without changing said distance therebetween in a predetermined moving manner to perform a zooming operation in each of said wide-angle range and said telephoto range.

5           8.     The lens distance-varying mechanism according to claim 7, wherein said first lens frame and said second lens frame, together with said differential linking ring, said differential ring and said biasing member, are supported by a support member which is linearly  
10 guided along said optical axis without rotating.

          9.     The lens distance-varying mechanism according to claim 1, wherein said first lens group and said second lens group serve as movable lens groups of a zoom lens system, and

15           wherein said zoom lens system comprises at least four movable lens groups including said first lens group and said second lens group, said first lens group and said second lens group being positioned between a frontmost lens group and a rearmost lens group of said four movable  
20 lens groups.

          10.    A lens distance-varying mechanism for varying a distance between a first lens group and a second lens group, said lens distance-varying mechanism comprising:

25           a first lens frame which holds said first lens group

and includes a first cylindrical portion, said first lens frame being linearly movable along an optical axis;

a second lens frame which holds said second lens group, said second lens frame being allowed to rotate  
5 relative to said first lens frame within a predetermined angle of rotation while being prevented from moving along said optical axis relative to said first lens frame, wherein said second lens frame includes a second cylindrical portion, one of said first cylindrical portion  
10 and said second cylindrical portion being fitted on the other;

a plurality of inclined cam edges formed on one of said first cylindrical portion and said second cylindrical portion at predetermined intervals in a circumferential  
15 direction, each inclined cam edge of said plurality of inclined cam edge being inclined to both said circumferential direction and the optical axis direction;

a plurality of cam followers formed on the other of said first cylindrical portion and said second  
20 cylindrical portion to be engaged with said plurality of inclined cam edges, respectively;

a biasing device for biasing said first lens frame in a direction to bring said plurality of cam followers into contact with said plurality of inclined cam edges,  
25 respectively, and

a drive system for driving said second lens frame to rotate forward and reverse.

11. The lens distance-varying mechanism according to claim 10, wherein a first recess and a second  
5 recess are formed on said one of said first cylindrical portion and said second cylindrical portion at opposite ends of each cam edge of said plurality of cam edges to hold an associated cam follower of said plurality of cam followers with stability.

10 12. The lens distance-varying mechanism according to claim 10, wherein said first lens group and said second lens group serve as movable lens groups of a zoom lens system,

wherein said relative-moving mechanism varies a  
15 distance between said first lens group and said second lens group between a first distance in a wide-angle range which ranges from a short focal length extremity to an intermediate focal length and a second distance in a telephoto range which ranges from said intermediate focal  
20 length to a long focal length extremity; and

wherein said first lens group and said second lens group move along said optical axis without changing said distance therebetween in a predetermined moving manner to perform a zooming operation in each of said wide-angle  
25 range and said telephoto range.

13. The lens distance-varying mechanism according to claim 12, wherein said first lens frame and said second lens frame are supported by a support member which is linearly guided along said optical axis without  
5 rotating, and

wherein the position of said support member in said optical axis direction is controlled by a cam ring which is driven to rotate,

said drive system comprising:

10 a linear guide ring which moves together with said cam ring along said optical axis while allowing said cam ring to rotate with respect to said linear guide ring;

a switching member which is positioned on a peripheral surface of said linear guide ring to be  
15 supported thereby to be relatively movable in a circumferential direction with respect to said linear guide ring within a predetermined angle of rotation about said optical axis;

a switching member moving mechanism for moving said  
20 switching member forward and reverse in said circumferential direction of said linear guide ring at an intermediate focal length in association with rotation of said cam ring; and

a movement transfer mechanism for transferring  
25 forward and reverse movements of said switching member in

said circumferential direction of said linear guide ring to said second lens frame to rotate said second lens frame forward and reverse, respectively.

14. The lens distance-varying mechanism  
5 according to claim 13, wherein said forward and reverse movements of said switching member cause said first lens frame and said second lens frame to vary a distance therebetween between a narrow distance and a wide distance.

10 15. The lens distance-varying mechanism according to claim 10, wherein said first lens group and said second lens group serve as movable lens groups of a zoom lens system.

16. A zoom lens having a zoom lens system  
15 including two movable lens groups which are moved relative to each other, wherein a distance between said two movable lens groups varies between a first distance in a wide-angle range which ranges from a short focal length extremity to an intermediate focal length and a second  
20 distance in a telephoto range which ranges from said intermediate focal length to a long focal length extremity,

said zoom lens comprises:

a lens group support unit which supports said two  
25 movable lens groups, said lens group support unit being



linearly guided along an optical axis; and

a cam ring driven to rotate for controlling the position of said lens group support unit in said optical axis direction;

5 a linear guide ring which moves together with said cam ring along said optical axis while allowing said cam ring to rotate with respect to said linear guide ring;

a switching member which is positioned on a peripheral surface of said linear guide ring to be supported thereby to be relatively movable in a circumferential direction with respect to said linear guide ring within a predetermined angle of rotation about said optical axis;

15 a switching member moving mechanism for moving said switching member forward and reverse in said circumferential direction of said linear guide ring at an intermediate focal length in association with rotation of said cam ring; and

20 a lens distance varying mechanism for varying said distance between said two movable lens groups between said first distance and said second distance in association with forward and reverse movements of said switching member at forward and reverse moving limits thereof, respectively.

25 17. The zoom lens according to claim 16, wherein

said switching member moving mechanism comprises:

a switching ring which rotates together with said cam ring;

a switching groove formed on an inner peripheral  
5 surface of said switching ring; and

a follower projection which projects from said switching member to be engaged in said switching groove.

18. The zoom lens according to claim 16, wherein said lens distance varying mechanism comprises:

10 a differential ring which rotates together with said switching member;

a rotating lens frame which supports one of said two movable lens groups, and rotates without moving along said optical axis by a rotation of said differential ring;  
15 and

a linear-moving lens frame which supports the other of said two movable lens groups, and linearly moves along said optical axis by a rotation of said rotating lens frame.

20 19. The zoom lens according to claim 18, wherein said switching member comprises a straight groove which is formed on an inner peripheral surface of said switching member to extend parallel to said optical axis, and

wherein said differential ring comprises a  
25 projection which projects radially outwards to be engaged

in said straight groove.

20. The zoom lens according to claim 16, wherein said linear guide ring comprises a guide slot in which said switching member is positioned so that an outer peripheral surface of said switching member is substantially flush  
5 with an outer peripheral surface of said linear guide ring.

21. The zoom lens according to claim 16, comprising a shutter unit which is fixed to said lens group support unit.

10 22. The zoom lens according to claim 16, wherein said first distance is wider than said second distance.

23. The zoom lens according to claim 16, wherein said zoom lens system comprises at least four movable lens groups, said two movable lens groups being positioned  
15 between a frontmost lens group and a rearmost lens group of said four movable lens groups.

24. The zoom lens according to claim 16, wherein said zoom lens is of a telescoping type zoom lens having a plurality of telescoping barrels.